XVII. *On different Sorts of Lime used in Agriculture.* By Smithson Tennant, *Esq. F. R. S.*

Read June 6, 1799.

I WAS informed last summer, that in the neighbourhood of Doncaster, two kinds of lime were employed in agriculture, which were supposed to differ materially in their effects. One of these, which was procured near the town, it was necessary to use sparingly, and to spread very evenly over the land; for it was said that a large proportion of it, instead of increasing, diminished the fertility of the soil; and, that wherever a heap of it was left in one spot, all vegetation was prevented for many years. Fifty or sixty bushels upon an acre, were considered to be as much as could be used with advantage. The other sort of lime, which was obtained from a village near Ferry-bridge, though considerably dearer, from the distant carriage, was more frequently employed, on account of its superior utility. A large quantity was never found to be injurious; and the spots which were entirely covered with it, instead of being rendered barren, became remarkably fertile. The different properties ascribed to these two kinds of lime were so very distinct, that it seemed probable they could not be imaginary; and it therefore appeared to be worth the trouble of ascertaining them more fully, and of attempting to discover the nature of the ingredients from

whence the difference arose. For this purpose, I procured some pieces of each sort of limestone, and first tried what would be their effect upon vegetables, in their natural state, by reducing them to coarse powder, and sowing in them the seeds of different plants. In both kinds, the seeds grew equally well, and nearly in the same manner as they would in sand, or any other substance which affords no nourishment to vegetables. Pieces of each sort of stone were then burnt to lime; and, after they had been exposed for some weeks to the air, that their causticity might be diminished, some seeds were sown in them. In the kind of lime which was found most beneficial to land, almost all the seeds came up, and continued to grow, as long as they were supplied with water; and the roots of the plants had many fibres, which had penetrated to the bottom of the cup in which they grew. Upon examining the composition of this sort of lime, it proved to consist entirely of calcareous earth. By its exposure to the air for about three months, it was found to have absorbed four-fifths of the fixed air required to saturate it. In the other kind, a few only of the seeds grew, and the plants produced from them had hardly any stalks or roots, being formed almost entirely of the two seed-leaves, which lay quite loose upon the surface. This sort of lime, being spread upon a garden soil, to the thickness of about the tenth of an inch, prevented nearly all the seeds which had been sown from coming up, whilst no injury was occasioned by common lime used in the same manner. Upon examining the composition of this substance, which was so destructive to the plants, it was discovered to contain three parts of pure calcareous earth, and two of magnesia. The quantity of fixed air which it had absorbed,

by being exposed for about the same time as the pure lime just mentioned, was only 42 hundredths of that combined with it before it was burnt.

As it seemed probable, that the magnesia contained in this lime was the cause of its peculiar properties, the following experiments were made, to determine the effects of that substance upon the growth of vegetables. Some seeds, chiefly of colewort, which were preferred from their growing quickly, were sown in uncalcined magnesia; but, though they sprouted, the leaves never rose above the surface, and the plants were entirely without roots: nor did they appear to grow better in magnesia which had been washed in water containing fixed air. Calcined magnesia was, however, much more destructive, as the seeds would not come up in it. To compare its effects on vegetables with those of lime, each of these earths was mixed, in different proportions, with sand, in small cups, in which, seeds were then sown. The lime was obtained from marble; and, before it was put into the sand, was made to fall to powder, by being moistened with water. In a mixture of four ounces of sand with three or four grains of calcined magnesia, it was a long time before the seeds came up, and the plants had hardly any roots or stalks; and, with ten grains or more of magnesia, there was no appearance of vegetation. Thirty or forty grains of lime did not retard the growth of the seeds more than three or four of magnesia, and the injurious effects were not so lasting. The lime, by absorbing fixed air, soon lost its destructive properties; so that, after keeping these mixtures four or five weeks, seeds were found to grow in that with forty grains of lime, nearly as well as in pure sand; but, in that with four grains of magnesia, they produced only the seed-leaves, as was

described before. It was necessary occasionally to break in pieces the sand which had so much lime, as it would otherwise have been too hard to admit the seeds to penetrate through it. Plants will bear a much larger proportion of magnesia in vegetable soil than in sand: with twenty grains, however, of calcined magnesia, in as much soil as was equal in bulk to four ounces of sand, the seeds produced only the seed-leaves, without roots; and, with about forty grains, they were entirely prevented from coming up.

In countries where the magnesian lime is employed, it was said, that the barrenness of any spot on which a heap of it had been laid, would continue for many years. To learn how far it could by time be deprived of its injurious qualities, I procured some pieces of mortar made of this species of lime, from two houses, one of which had been built three, and the other eight years: they were taken from the outside of the building, where they had been exposed to the air. After they were reduced to powder, seeds were sown in them. Only a few came up, and even those produced merely the seed-leaves, without any roots. As plants would grow in the limestone from which this species of lime was formed, although not in the mortar made from it, I wished to know what proportion of the fixed air originally contained in the limestone, had been absorbed by the mortar. For this purpose, a piece of it was finely powdered, to render it of an uniform quality: it was then tried how much of this powder and of the limestone would saturate the same quantity of acid: by this means, I ascertained the proportions of limestone and mortar containing equal quantities of the magnesian lime. The fixed air being obtained from them in those proportions, and measured in an inverted vessel,

with quicksilver, it was found, that the mortar which had been exposed three years had absorbed 43, and that of eight years, only 47 hundredths of the quantity originally contained in the limestone. I was not able to obtain any mortar which had been made earlier, though it might deserve to be known how much fixed air it was ultimately capable of absorbing. Common mortar, which had been exposed to the air for a year and three quarters, had regained 63 hundredths of its full quantity of fixed air.

As the preceding experiments were tried during the winter, in a room warmed by fire, perhaps, under circumstances more favourable to vegetation, the same quantity of magnesia would not be equally pernicious.

Magnesian limestone may be easily distinguished from that which is purely calcareous, by the slowness of its solution in acids, which is so considerable, that even the softest kind of the former is much longer in dissolving than marble. From this property of the magnesian limestone, there appeared to be reason for suspecting that the kind of marble which had been called Dolomite, from M. DOLOMIEU, who first remarked its peculiarity in dissolving slowly, might also be similar in its composition. An analysis of this substance was lately given in the *Journal de Physique*, but this is probably erroneous; for, upon examining three specimens, they were found to consist of magnesia and calcareous earth, like the magnesian limestone; so that it ought, no doubt, to be considered as the same species of stone, but in a state of greater purity. The pieces of Dolomite were from different places; one of them being found among the ruins of Rome, where it is thought to have come from Greece, as many statues of Grecian workmanship are made of

it, and no quarries of a similar kind are known in Italy; the second was said to have been thrown up by Mount Vesuvius; and the third was from Iona, one of the western islands of Scotland. In many kinds of common marble, small particles and veins may be observed, which are a long time in dissolving. These, upon examination, I discovered to contain a considerable proportion of magnesia; but, as they were probably not quite free from the surrounding marble, I did not ascertain the quantity precisely.

The crystallized structure which may generally be observed in the magnesian limestone, seems to shew that it has not been formed by the accidental union of the two earths, but must have resulted from their chemical combination. The difficulty of dissolving it, may also arise from the attraction of the different component parts to each other. The mortar formed from this kind of lime, is as soluble in acids as common marble; and the substances of which it consists are easily separated. The magnesia may be taken from it by boiling it in muriated lime, and lime is precipitated by it from lime water; but neither of these effects can be produced by the stone, before it is calcined.

Magnesian limestone is probably very abundant in various parts of England. It appears to extend for thirty or forty miles, from a little south-west of Worksop, in Nottinghamshire, to near Ferry-bridge, in Yorkshire. About five or six miles further north there is a quarry of it, near Sherburn; but, whether this is a continuation from the stratum near Ferry-bridge, I have not learnt. From some specimens which were sent me, I find that the cathedral and walls of York are made of it. I have not been able to learn whether there were any shells in the limestone of the tract of country before mentioned. In Mr.

MARSHALL's account of the agriculture of the midland counties, he speaks of the lime made at Breedon, near Derby, as destructive to vegetables, when used in large quantities. I therefore procured some pieces of it, and they were discovered to contain nearly the same proportion of magnesia as that before described. In this quarry, the stone is frequently crystallized in a rhomboidal form; and petrified shells, not calcareous, but similar in composition to the stone itself, are sometimes, but very rarely, found in it. This substance seems to be common in Northumberland. In the third volume of the Annals of Agriculture, Dr. FENWICK, of Newcastle, observes, that the farmers of that country divide limes into hot and mild. The former of these is no doubt magnesian, as it has similar effects on the soil; and he remarks, that it is not so easily dissolved in acids as the latter. At Matlock, in Derbyshire, the two kinds are contiguous to each other; the rocks on the side of the river where the houses are built being magnesian, and on the other, calcareous. The magnesian rock appears also to be incumbent upon a calcareous stratum; for, in descending a cave formed in this rock, a distinct vein of common limestone may be observed, which contains no magnesia. The latter stratum is very full of shells; but, though there are some also in the magnesian rock, yet they are very rare. In the following tables, containing the analysis of various specimens, some other places are mentioned where this substance is found, but of which I received no further information.

After it was known that the magnesian marble and limestone consisted of the two earths, their proportion was attempted to be discovered, by trying how much gypsum and Epsom salt could be obtained, by means of vitriolic acid, from a certain

weight of each specimen. When the superfluous vitriolic acid had been evaporated by heat, the Epsom salt was separated from the gypsum by water. The result of these trials is expressed in the following table.

	Dry gypsum.	Dry Epsom salt.
5 grains of limestone from Breedon gave	3.9	3.15
——— Matlock -	3.95	2.9
——— Worksop -	3.8	3.0
——— York -	3.8	3.1
3 grains of calcareous spar and 1 grain of calcined magnesia gave - -	3.9	2.7

As the preceding method of estimating the quantities of magnesia and calcareous earth is liable to considerable error, I afterwards examined them in the following manner, which seems capable of great exactness. Twenty-five grains of each substance were dissolved by marine acid, in a cup of platina, and, after the solution was evaporated to dryness, it was made red hot for a few minutes. The mass remaining in the cup, which consisted of muriated lime, and of the magnesia freed from the acid, was washed out with water, and poured into a phial. There was then added to it a known quantity of diluted marine acid, somewhat more than was sufficient to redissolve the magnesia, and, after the solution, a certain weight of calcareous spar, part of which would be dissolved by the superfluous acid. By the quantity of spar remaining undissolved, it was learnt how much acid was required to dissolve the magnesia. The iron and argillaceous earth contained in some specimens, were precipitated by the spar, and therefore could not occasion any error. The calcareous spar, however, dissolved more slowly where there was argillaceous earth, as it became coated with it; but this incrustation was occasionally removed, and, in all the experi-

ments, the spar was left in the solution till it suffered no further diminution. For this purpose, it was necessary to keep them slightly warm for some days, during which time, the phials were generally closed, to prevent any escape of the acid.

The first experiment in the following table was made upon known quantities of magnesia and calcareous earth, to try the accuracy of the process. For this purpose, also, the second was repeated upon a piece of limestone, previously powdered, to render every part of it of the same quality. The first column shews the quantity of calcareous spar which might have been dissolved by the acid required to take up the magnesia. The second shews the corresponding quantities of magnesia in 25 grains of each substance. The third expresses the quantity of lime. This was inferred by subtracting the weight of the magnesia, and of the iron and clay, from 13.2 grains, the weight of the whole quantity of earth in 25 grains of limestone. This is probably not very incorrect, as, in two specimens which differed most in the proportion of magnesia and lime, the weight of the two earths was nearly the same.

A piece of Dolomite, from Rome, was wrapped in a thin leaf of platina, that no part of it might be lost, and, being then exposed to a strong heat, left of earth - 52.9 per cent.

Dolomite from Mount Vesuvius -	52.8
Breedon limestone - - -	52.4
Calcareous spar left of lime - -	55.8

In three of the experiments, also, the calcareous earth was precipitated by mineral alkali; and the quantity of it being tried by that of the marine acid required to dissolve it, it corresponded very nearly with that put down.

A quantity of marine acid which would dissolve 15 grains of calcareous spar, would also dissolve 5.5 of calcined magnesia, and

2.5 grains of spar; so that, 12.5 grains of spar required the same quantity of acid as 5.5 grains of magnesia.

The magnesia used was very pure, and made red hot immediately before it was weighed.

Substances examined.	Quantity of spar which the acid, required to take up the magnesia, would have dissolved.	Quantity of magnesia.	Quantity of lime.	Iron and clay.	
Mixture of 5.5 grains of magnesia and 14 grains of calcareous spar - - -	12.5	5.5	7.8	0	
25 grains of Breedon limestone, previously powdered	11.53	5.071	7.929	.2	
25 grains from part of the same powder - -	11.56	5.082	7.913	.2	
25 grains of Dolomite from Rome - - -	12.2	5.37	7.73	.1	
——— Dolomite from Iona - - - -	10.1	4.4	7.8	1.0	Insoluble substance.
——— Vesuvian Dolomite - - - -	10.38	4.565	8.575	.06	
A second experiment, from part of the same Vesuvian Dolomite - - -	10.03	4.411	8.849	.06	
25 grains of magnesian limestone from Wansworth, near Doncaster - - -	12.75	5.61	7.34	.25	
——— Thorpe arch -	10.95	4.84	7.8	.6	
——— Matlock -	12.5	5.5	7.388	.31	
——— York minster -	11.	4.84	8.26	.1	
——— Worksop -	11.6	5.104	7.496	.6	
——— Sherburn -	11.5	5.08	7.56	.56	
——— Westminster-hall	10.1	4.44	8.37	.4	